Systems Engineering National Capability Roadmap Status

Public Workshop

November 30, 2004

Systems Engineering Definition (NASA SP-6105)

Systems engineering is a robust approach to the design, creation, and operation of systems. In simple terms, the approach consists of identification and quantification of system goals, creation of alternative system design concepts, performance of design trades, selection and implementation of the best design, verification that the design is properly built and integrated, and post-implementation assessment of how well the system meets (or met) the goals. An important aspect of this role is the creation of system models that facilitate assessment of the alternatives in various dimensions such as cost, performance, and risk.

The objective of systems engineering is to see to it that the system is designed, built, and operated so that it accomplishes its purpose in the most cost-effective way possible, considering performance, cost, schedule, and risk.

One Last Systems Engineering Definition (as defined in Draft Roadmap Content paper)

Systems engineering is decision making for the development of complex systems through leadership, engineering processes and methods. The final decisions must be based on the NASA's stakeholders Level 0 requirements of **safety, affordability, and sustainability and the risk of meeting these requirements**. (It should be noted that affordability is a strong function of safety and sustainability is a strong function of cost, safety, and risk). Engineering analyses, tests, and demonstrations must be orchestrated in an ordered technology/capability/system/architecture/super systems maturation (spiral) process to provide information for technical decisions while balancing safety, cost, and risk.

The problem with making decisions on the Level 0 requirements and the risk of meeting these requirements is that these particular Level 0 Figures of Merit (FoMs) are extremely difficult to analyze especially at the conceptual level. The General Accounting Office (GAO) report on NASA's cost estimating shows a 77% mean overrun. Current state of the art of safety and reliability analysis at the conceptual phase (even at the operational phase) can easily be orders of magnitude in error. Finally risk is even more nebulous because it is based on the impact of the technologies/capabilities/systems etc. on these difficult to analyze FoMs and the probability of obtaining their technical performance projected in the future, which is obtained through expert opinion.

Why is this Capability important?

(see quotes from National Academies Committee on Systems Integration for Project Constellation dated 9-21-04)

Strengthening the state of systems engineering is also critical to the long-term success of Project Constellation. A competent systems engineering capability must be resident within the government and industry. The U.S. Department of Defense essentially eliminated its systems engineering capability as a result of acquisition reforms implemented in the 1990s. NASA's human spaceflight systems engineering capability has eroded significantly as a result of declining engineering and development work, which has been replaced by operational responsibilities. Industry has a credible systems engineering capability, but it is being stressed by the need to modernize almost all national security space programs. The demand for experienced systems engineers, who can function credibly in a system-of-systems environment, is particularly acute.

Understanding the state of systems engineering is of the utmost importance in selecting management concepts for implementing Project Constellation. ***Plans should be developed for maintaining a satisfactory base of systems engineering throughout the duration of this program.***

Systems Engineering Team Membership

Steve Cavanaugh, LaRC, NASA Chair

Alan Wilhite, Georgia Tech, External Chair

Chuck Weisbin, JPL, Systems Engineering/Tech Development Risk

Dave Bearden, Aerospace Corp, Life Cycle Cost-Risk

Dale Thomas, MSFC, Systems Engineering-Risk

Gaspare Maggio, SAIC, Safety-Risk

Steve Creech, MSFC, Life Cycle Cost

Edgar Zapata, KSC, Operations, Cost, and Risk

CAPT Daven Matsen, DoD, Chief Architect of Space Systems

Mr. Rick Westermeyer, DoD, National Security Space Office

Dr Steve Meier, DoD, National Reconnaissance Office

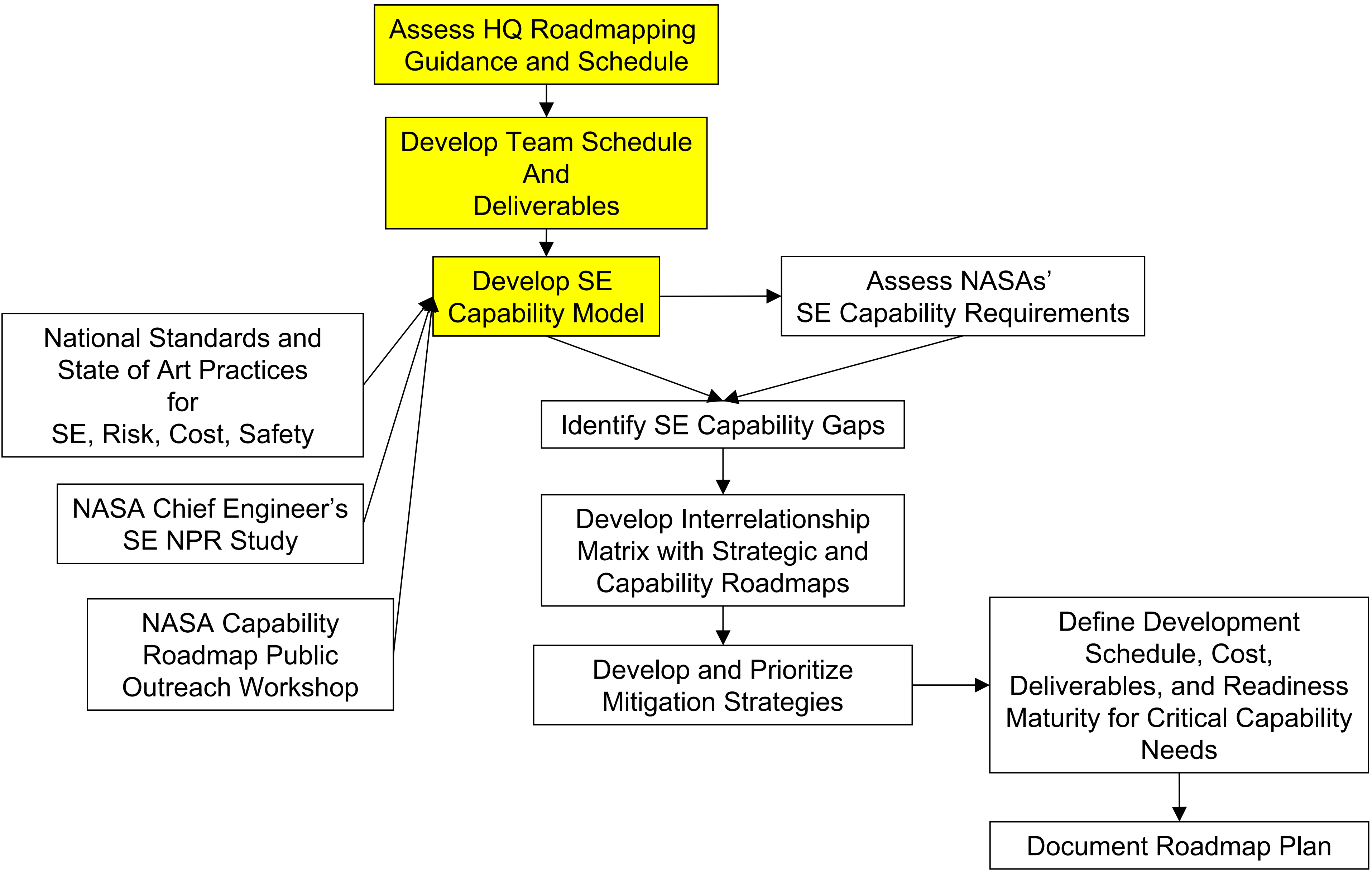
Stephen Prusha, JPL, Advanced modeling, simulation, analysis roadmap team Liaison

Vicky Hwa, HQ/ESMD, Technical Manager

Betsy Park, HQ/ESMD, Systems Integration

Vicki Regenie, JPL/APIO, Systems Engineering-APIO Coordinator

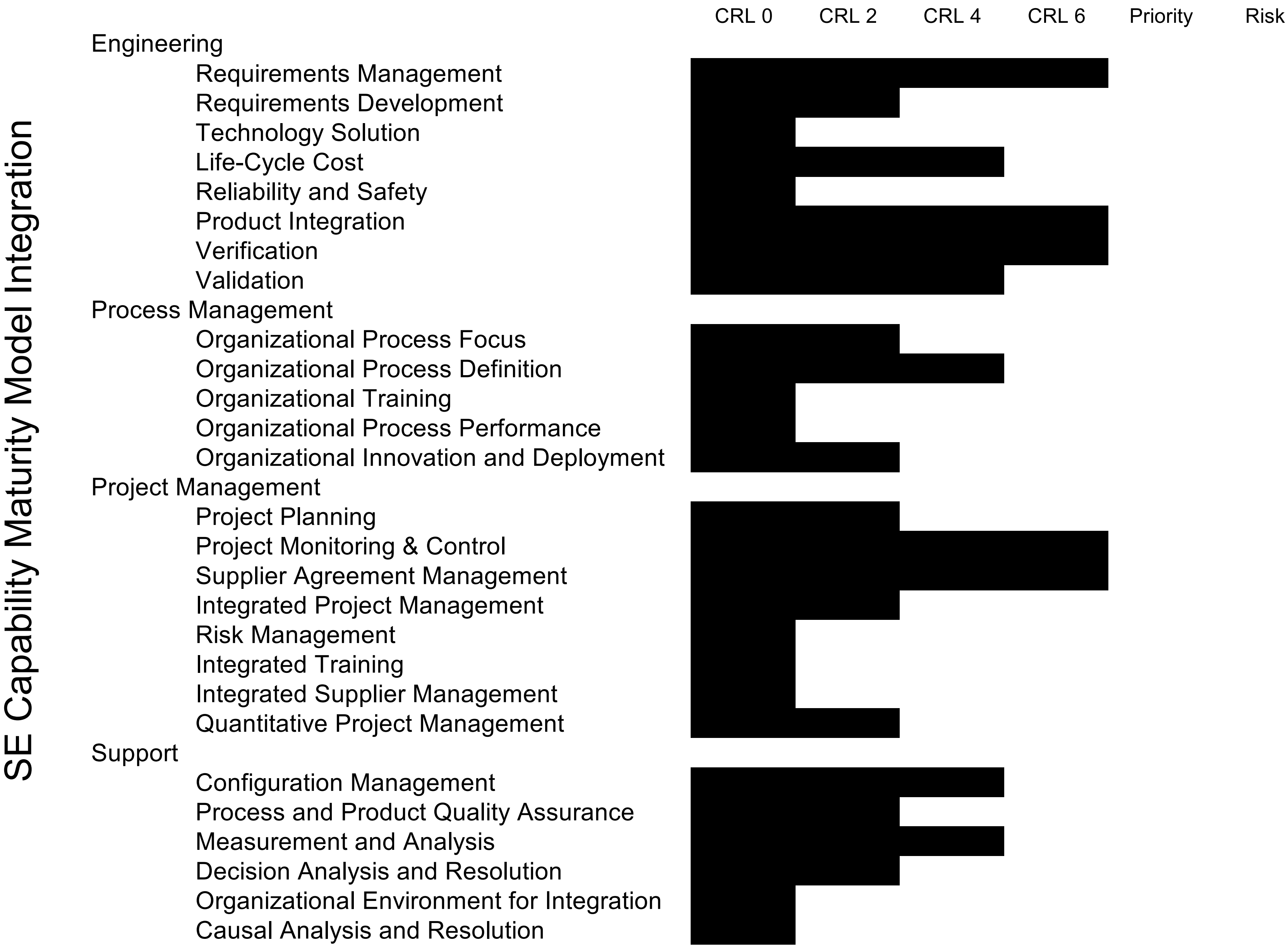
Systems Engineering Roadmapping Plan



Capability Assessment Process

- **Develop capability model**
  - **Define technology, people skills, process, method, and/or tool areas**
  - **Define scale for rating current status for each sub-capabilities**
    - **1-5 with description for each level**
- **Rate each sub-capability**
- **Define:**
  - **Priorities (importance) of sub-capabilities**
  - **Capability Readiness Levels (CRL) and rate CRL for each sub-capability**
  - **Final goal for each sub-capability and steps to achieve the goal**
  - **Schedule and cost for each step**

Initial Systems Engineering WBS & Draft Capability Assessment Process



Draft Roadmap Content

- **Assessment of Systems Engineering (SE) requirements for super systems, architectures, systems, capabilities, and technologies**
  - Goal definition, Requirements allocation and flowdown, Cost/benefit/risk analysis, and Contingency analysis
- **Gap assessment of state of the art cost, safety, risk methods and tools for supporting NASA's vision with SE requirement**
  - Develop requirements and plan for development
- **Integration with the Modeling and Simulation Capability Team**
  - What is NASA's current capability status in Modeling and Simulation?
  - What are the system engineering requirements for M&S?
- **Interaction/integration of SE cost, safety, and risk requirements**
  - What are NASA's current expectations of cost, safety, and risk? Compare to Apollo and DoD.
  - What are the data requirements for integration?
  - Verification and validation
    - What is the current cost, safety, and risk database?
    - Can NASA get all available data from DoD and industry?
    - What are the critical tests and demonstrations needed to fill in the gaps?
    - What is the level of accuracy that can be achieved?

Systems Engineering Status

- Assessed Headquarters' roadmap guidance and schedule
- Selected team membership
- Developed:
  - Schedule and deliverables
  - Work Breakdown Structure
  - Roadmap plan
- First team workshop scheduled for December 7-8, 2004

Summary of White Paper topics

- Verification (1)
- Integrated Analysis (4)
- Cost (3)
- Risk (6)
- Schedule (1)
- Tools (6)
- FFRDC (1)
- Education and Training (2)
- Operations (1)
- Environmental (2)

Questions & Answers